DOCUMENT RESUME

ED 283 170 CS 210 588

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TITLE Technical Writing across the Curriculum: Epics.
PUB DATE Mar 87
NOTE 12p.; Paper presented at the Annual Meeting of the Conference on College Composition and Communication (38th, Atlanta, GA, March 19-21, 1987).
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Content Area Writing; *Course Content; Educational Innovation; *Engineering Education; Higher Education; Program Content; *Program Development; Program Guides; *Technical Writing; *Writing Instruction

ABSTRACT

Noting that technically competent graduates of professional schools need additional skills to function effectively in an increasingly complex and global society, this paper describes an innovative program in technical writing developed for undergraduate engineering students at the Colorado School of Mines. The paper first provides background information and a rationale for the implementation of the EPICS (Engineering Practices Introductory Course Sequence) program. A figure illustrating the content of all four semesters of the course sequence is included. The paper then presents a detailed description of the makeup and activities of the introductory first semester course, EP 101. Next, the paper supplies a brief overview of all the tracks--mapping, graphics, computing, and projects/communications--that comprise the course sequence, followed by a model for and discussion of a decision-making design method, particularly applicable to engineering students, used in EP 101. Activities undertaken in the second semester of the course (EP 102) are then described. The remainder of the paper deals with the third semester (EP 201) computing and graphics integration, as well as with diverse projects that make up the work of the fourth semester (EP 202). The paper concludes by addressing the areas in the EPICS program that could be improved. (NKA)

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TECHNICAL WRITING ACROSS THE CURRICULUM: EPICS

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by

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Nearly ten years ago, the Colorado School of Mines undertook an exhaustive study of its undergraduate engineering curriculum among alumni, faculty, and students. The results were mixed: all of those surveyed concluded that our graduates were technically competent, indeed outstanding. However, there was concern that our graduates needed other skills in order to function as effective professionals in an increasingly complex and global society. Specifically, the survey (known as the Profile of the Future Graduate, edited by Prof. Rex Bull) targeted the following abilities as necessary for the ideal engineer:

- communication skills
- ability to self-educate
- ability to solve open-ended problems
- awareness of non-technical influences
- sensitivity to cultural and social differences
- integrity and self-discipline

To their credit, the CSM faculty began to look for innovative ways to implement the Profile, and among the more successful results has been the EPICS (Engineering Practices Introductory Course Sequence) program. Developed with the help of an Exxon education grant by Richard Culver, JoAnn Hackos, Robert Taylor

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and others, the program became a required course for all CSM freshmen and sophomores during the 1986-1987 academic year.

EPICS is a four-semester, eleven credit, two year sequence which integrates instruction in technical writing, oral communication, computing, graphics, and mapping with work on a series of bona fide engineering projects of increasing complexity. The EPICS sequence has several advantages over the separate courses which it replaces:

- It truly integrates work on projects with communication skills. Technical writing strategies are introduced when they apply to work students are doing on projects.
- It defines "communication" broadly, in an engineering context: computing, mapping and graphics are communications processes, just as writing and speaking are.
- It emphasizes open-ended problem solving by including a series of engineering projects which have no one "right" answer.
- It allows students to develop skills over four semesters.
- It minimizes class lecture time and maximizes "hands on" experiences. Teachers function as coaches or managers.

As with any innovative program, especially interdisciplinary ones, introducing EPICS meant solving some logistical problems; separate courses in separate departments had to be integrated into one coherent course. Graphics, mapping, computing, and technical writing courses were blended with an emphasis on developing problem-solving skills. The resulting courses are illustrated by Figure 1 below.

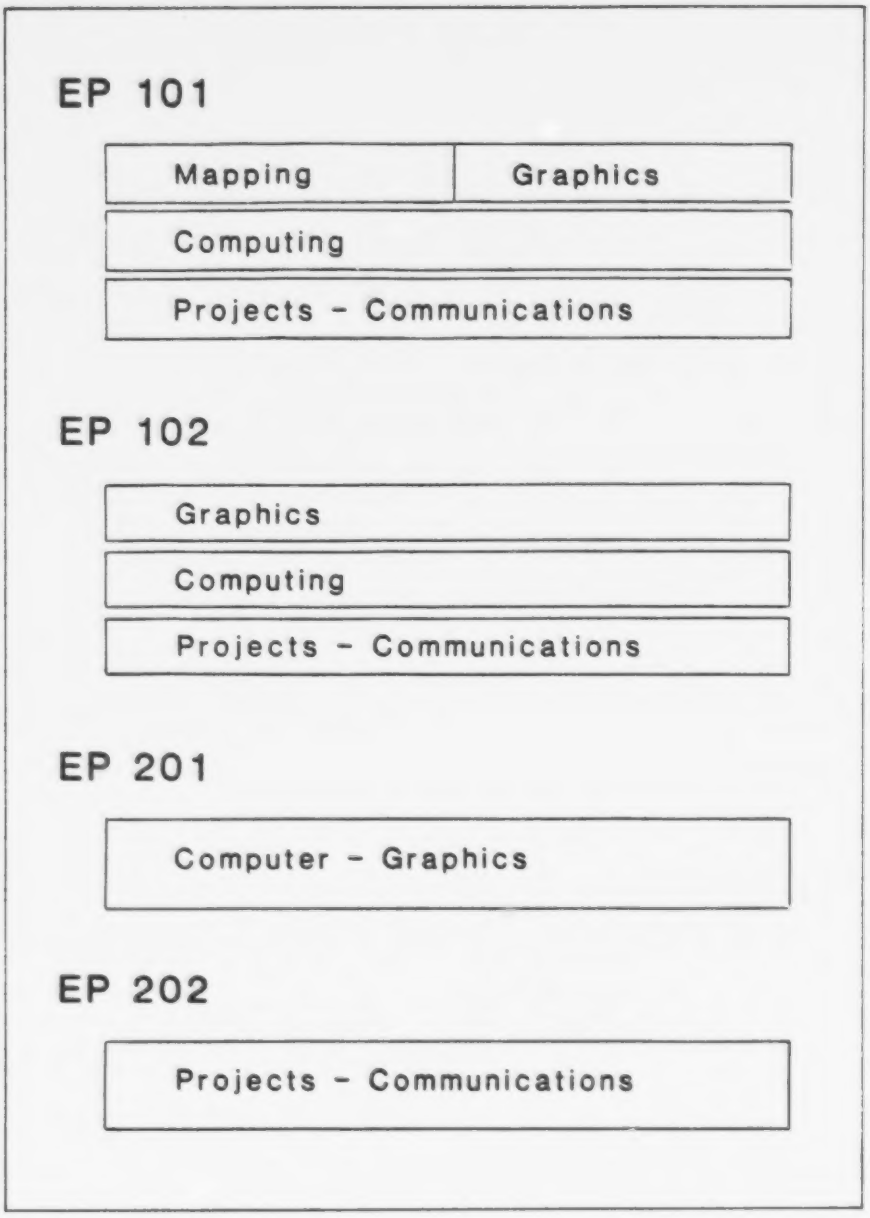

Figure 1

Students take four semesters of EPICS during their freshman and sophomore years.

During the first semester, students spend six hours a week in EPICS, earning 3 hours of credit for a lecture/lab course. Each EPICS class contains a total of up to 120 students broken

into three sections of approximately 40 students each. The forty students in a section stay together for all of their EPICS meetings. Each of the rectangles on Figure 1 represents one two-hour block of time devoted to a single subject, called a track. One section of students attends the mapping track on Monday for the first half of the semester, then the graphics track for the second half. They attend computing for two hours every Wednesday and the Projects/ Communications track every Friday. Another group has Graphics/Mapping on Wednesday, Computing on Friday, and Projects/ Communications on Monday. Each track has separate instructors who repeat the same material three times each week to different groups of students. Five instructors would teach EP101: one each for Mapping, Graphics, and Computing and two for Projects/ Communications. EP102 has a similar structure.

In EP 201 and 202, the sopohomore classes, students work in sections of approximately 40 which two or three instructors. They attend class for four hours per week, in two two-hour blocks.

A brief overview of all of the tracks might be helpful before we examine how they all come together in the Projects/ Communications track.

Mapping. This seven-week session, taught by the Military Science Department, teaches the students to read and understand military and USGS topographical maps, useful skills for future engineers.

Graphics. This track takes an innovative approach to the old

engineering graphics course by focusing during the first semester on sketching and visualization, using Betty Edwards' book "Drawing on the Right Side of the Brain as a text. In the second semester, more traditional drafting methods are introduced. In the 201 course, students learn the theory and practice of effective computer-aided graphics including the use of sophisticated CAD and spread sheet software.

Computing. This track, in the freshman year, introduces the students to problem solving using computers. They learn to program in Basic and Fortran on both a PC and a mainframe. The course emphasizes flexibility and design since students will be exposed to new languages and new software in their professional life. In the third semester their computer work is integrated with graphics as they learn CAD and spread sheet graphics.

Projects/Communications. This is the part of EPICS most directly concerned with written and oral communication. In developing this part of the course the program originators asked: "How can we prepare our students to be good communicators in the context of the engineering profession? Their answer was to place the students in an engineering context as early in their careers as possible.

Beginning in the first semester, the students integrate communication skills with problem-solving skills to solve genuine engineering problems for outside clients. The Project/ Communications tracks are always team-taught by a member of the engineering faculty and a technical communications expert. The

amount of guidance and structure given by the instructors ranges from a great deal in the first semester to only a little in the final sophomore semester. At the same time, the technical complexity of the projects ranges from minimal during the first semester to quite sophisticated during the final semester. All of the projects, however, share certain qualities:

- They have real technical content, though the level varies considerably.
- They have a real client audience.
- They are genuinely open-ended, with no one, obvious "right" answer.
- They usually contain non-technical constraints: money, ethics, environmental impact, politics.

An overview of the types of projects and communication assignments in each EPICS course might be helpful.

EP 101

1. In this introductory course, the students first learn a decision-making process which they apply to a case study. We use Charles Wales' Guided Design method which seems particularly applicable to engineering students, though we are quick to point out that experienced decision makers do not follow any process lockstep. A modified version of Wales' process is reproduced below (Figure 2).

GUIDED DESIGN STEPS FOR DECISION-MAKING

- Get Information
- Identify Problem

- Find Objective or Goal
- State Constraints, Assumptions, Facts
- Generate Possible Solutions
- Evaluate and Decide
- Convince or Implement

Figure 2

Modified version of Charles Wales' Guided Design process.

2. Once they are familiar with the decision-making process, the students spend the remainder of the semester solving a problem for an outside client. In this first semester, as in following ones, the students work in teams to produce solutions. This early introduction to collaborative problem-solving is one of the strengths of EPICS, since we know that engineers often work in teams in the workplace and very few of them have college experience with teamwork.

The projects in this part of EPICS have relatively small technical content. In addition, the instructors find and provide the students with whatever outside resources they need; the emphasis here is on learning to work in teams and learning to solve problems which don't have easy, "right" answers.

Recent projects in this area have included taking a ten-year general plan for CSM campus improvement and developing full-scale plans for one part of the campus (client: CSM Director of Physical Plant) and planning uses for surface water run-off in a fast-developing part of the county (client: Jefferson County Planning Office).

In the communication area, students are introduced to several important elements of technical writing during this semester:

- audience analysis
- a group outlining technique
- keyword analysis

In addition, they write a final report on the project and make a final oral presentation. During the semester, we introduce time management and group dynamics strategies as well.

EP 102

During the second semester the students again work on one open-ended problem, this one more technical. At this point we provide them with one or two pieces of key source material, introduce them to the use of the library, and require them to find additional sources. We stress the importance of human resources as well as written ones. This past year EP 102 students worked on such diverse projects as the feasibility of installing solar-powered outdoor privies at Forest Service sites and designing a new traffic interghange at a busy downtown intersection for the Denver Traffic Safety office.

During this semester, students learn a comprehensive editing system, repeat the organizational strategies they learned the previous semester, and write two reports--one at midterm and one at the end of the semester. Once again they work in teams in solving the clients' problems. Oral communication is stressed during this semester; the students make four presentations in a small-group format, two of which are video-taped and reviewed.

EP 202

EP 201 concentrates on integrating computing and graphics, which leads logically into the final EPICS course, EP202, where all of the skills which the students have been practicing for the past two years in computing, graphics, communications, and problem-solving are brought together in solving a problem for an outside client.

Clients for this class are recruited from industry, government, and universities. In the past, they have all been from the Denver area, but this year, with the help of an NSF grant, we have used a data and voice transmission system to work with clients in Washington, D. C. and Bartlesville, OK. During this semester, the instructors in the course serve more than ever as coaches and consultants, not technical experts. The students select their own projects from among those solicited by the instructors, again work in teams and produce meeting minutes, progress reports, letters to clients, area reports and final reports. They also present their findings to the client orally, usually at the client's place of business.

Clients are generally very pleased with the quality of the students' work and with the contributions they make to the solution of a complex problem. The students are pleased to be working on "real problems" for "real clients" and they get a good sense of how things go in the workplace, including the usual glitches, delays, and misunderstandings.

Among the recent 202 projects:

TOXIC SLUDGE — Manufacturing aluminum cans produces sludge with moderate concentrations of heavy metals.

	What should be done when future EPA regulations classify the sludge as toxic waste?
MILITARY SCIENCE FACILITIES	Current Military Science facilities at CSM are in a 45-year-old "temporary" building in need of repair. A new home for the department is not in CSM's master plan. What is the best approach to the problem? Moving? Renovating the current building? Building a new facility?
SILVER PLUME BOULDER	The town of Silver Plume, Colorado sits directly under a large mass of rock which is apparently slowly breaking free. How urgent is the problem? What measures are recommended?

EPICS prepares our students well as apprentice engineers. It does, however, have its areas which could be improved:

1) The classes are very large, especially in the 101 and 102 sections. Even with two instructors, 40 students is a large number to deal with at one time.

2) Student workload has sometimes been too much; especially in the early years of the program, students complained that they were now taking three courses and getting credit for one! Faculty have worked hard to make workload and expectations realistic, and many of these complaints have been eliminated.

3) The grading load can be very high at peak periods, even with two faculty members per project/communication team.

4) The integration which was a cornerstone of the program hasn't

always happened, especially in the first two semesters. EP 202 has been very successful in tying together computing, graphics, communication, and problem-solving. EP201 integrates graphics and computing well. However, the first two semesters remain essentially separate courses. This may be necessary, but it may also be that we could do more creative integration.

Despite a few problems, EPICS has been very successful according to students, faculty, and outside evaluators. At the end of the two year sequence our students have confidence in their technical communication abilities and find themselves equipped to deal with many components of the professional world including writing reports, working in groups, solving open-ended problems, and making oral presentations. Best of all they see the value of communication skills because they have used them in an engineering context.